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Heavy Mineral Ratios of Sangamon Weathering Profiles in Illinois

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HEAVY MINERAL RATIOS OF SANGAMON WEATHERING PROFILES IN ILLINOIS

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ABSTRACT

Heavy mineral ratios were studied to compare the degree of weathering attained in buried Sangamon profiles developed on Illinoian till with that in profiles developed on Illinoian outwash. Grain sizes were determined and heavy minerals were analyzed for 59 samples from four sections. Two of the sections were from profiles developed on clayey till and two from profiles developed on outwash, one of the latter being dominantly sand and gravel, the other silt overlying sand, silt, and gravel. The sections sampled had similar topographic positions so that differences in soil-forming factors, other than texture of parent material, probably were not great.

In terms of depletion of hornblende and garnet, the relatively coarse-grained, open-textured outwash proved to be considerably more weathered than the till. In the zone of greatest weathering about 90 percent of the hornblende had been removed from the outwash but only 60 percent had been removed from the till. About 70 percent of the garnet also had been weathered from the outwash, but the amount of garnet in the weathered till had not been noticeably reduced.

In the till profiles the original illite and chlorite were altered almost completely to montmorillonite.

INTRODUCTION

Previous investigations (Goldich, 1938; Dryden and Dryden, 1946) have established that minerals differ considerably in their degree of stability in the zone of weathering. Ruhe (1956) used this fact in setting up "weathering ratios" - the ratio of number of grains of relatively stable minerals to number of grains of relatively unstable minerals. He found that such ratios were higher in the upper portions of profiles than in the parent material and that the difference was greater in older profiles than in younger ones.

The objective of the present study was to determine the effect of variations in texture of parent material on degree of weathering as measured by weathering ratios. The relation of the weathering ratios to variations in clay mineralogy also was studied. The study is based on Sangamon weathering profiles on Illinoian drift.

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versity of Illinois, for discussion of pedological problems; and to Herbert D. Glass, Illinois State Geological Survey, for discussion of problems of clay mineralogy.

PROFILE SELECTION

To evaluate the influence of the texture of the parent material on the degree of weathering that had occurred in the Sangamon profiles, profiles were chosen that exhibited great differences in parent material. Two of the profiles were developed in till and two were developed in outwash. As nearly as could be determined, there were only minor differences in the other factors of weathering, as noted below.

Climate.- Within the sampling area (fig. 1), the climate probably was reasonably uniform during the period of profile development.

Topography. - All the profiles studied were developed on flat or nearly flat uplands.

Time. - All four profiles were developed on Illinoian drift after ice withdrawal and prior to burial by Wisconsin age loess.

Biota. - There is little direct evidence, but it is assumed that if climate and topography were similar, differences in biota would not have been great.

FIELD STUDY

The four profiles were described (see appendix) and sampled vertically according to zones that were recognizable in the field (table 1 and fig. 2).

Table 1. - Zonation of Buried Profiles of Weathering (Modified from Leighton and MacClintock, 1930)

Zone	Description
I.	Former surface zone, less clayey than zone II. Generally shows mixed-zone contact with overlying loess.
II.	Characterized by clay enrichment and often by structural development; pebbles, less common than in zone III, are dominantly dense, fine-grained silicates.
III.	Oxidized and leached of carbonates.
IV.	Oxidized.
V.	Apparently unaltered.

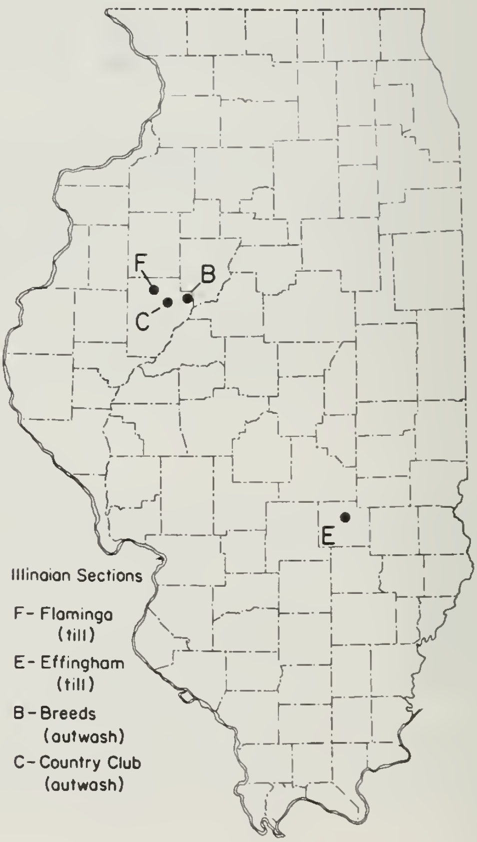

Fig. 1. - Location of sections studied.

LABORATORY METHODS

Standard pipette and screening methods were used to obtain grain-size distribution data for all samples (figs. 3-6 and appendix table A). The very fine sand (<.125 mm >.062 mm) was selected for heavy mineral studies because it contained the highest concentration and the greatest variety of heavy minerals. Part of the heavy-mineral yield of each sample was mounted in balsam, and a combined total of 300 grains of garnet (Ga), zircon (Zi), tourmaline (To), and hornblende (Hb) was counted under a polarizing microscope.

SELECTION OF WEATHERING RATIOS

The high resistance to weathering of zircon and tourmaline and the low resistance of hornblende are well documented (Jackson and Sherman, 1953), indicating that the ratio of zircon-plus-tourmaline to hornblende could be an effective index of weathering. The literature is not in agreement, however, on the resistance of garnet, so it was compared with high-resistance minerals by using the ratio of zircon-plus-tourmaline to garnet, and with low-resistance minerals by using the ratio of garnet to hornblende. Weathering ratios for each sample and grain counts from which they were calculated are listed in table B of the appendix.

VERTICAL VARIATIONS IN WEATHERING RATIOS

Figures 7 through 10 show curves produced by plotting weathering ratios versus depth. The general pattern of these curves is random variation upward through zones V, IV, and III, indicating little or no weathering loss of hornblende or garnet in these zones. Above zone III, however, marked changes are evident. In the Flamingo and Effingham till profiles, the ratios of zircon-plus-tourmaline to hornblende, and of garnet to hornblende, show increases, but the zircon-plus-tourmaline to garnet ratio continues its random variation. In the Breeds and Country Club outwash profiles, all three ratios increase in zones II and I.

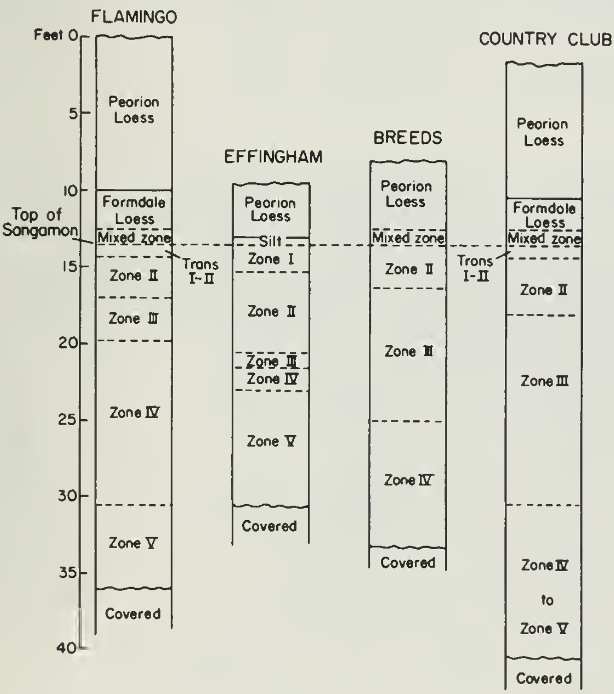

Fig. 2. - Columnar sections correlated on top of the Sangamon weathered zone.

COMPARISON OF DEGREE OF WEATHERING

In figures 11 and 12 the weathering ratio curves have been mathematically reduced to a common base for direct comparison.

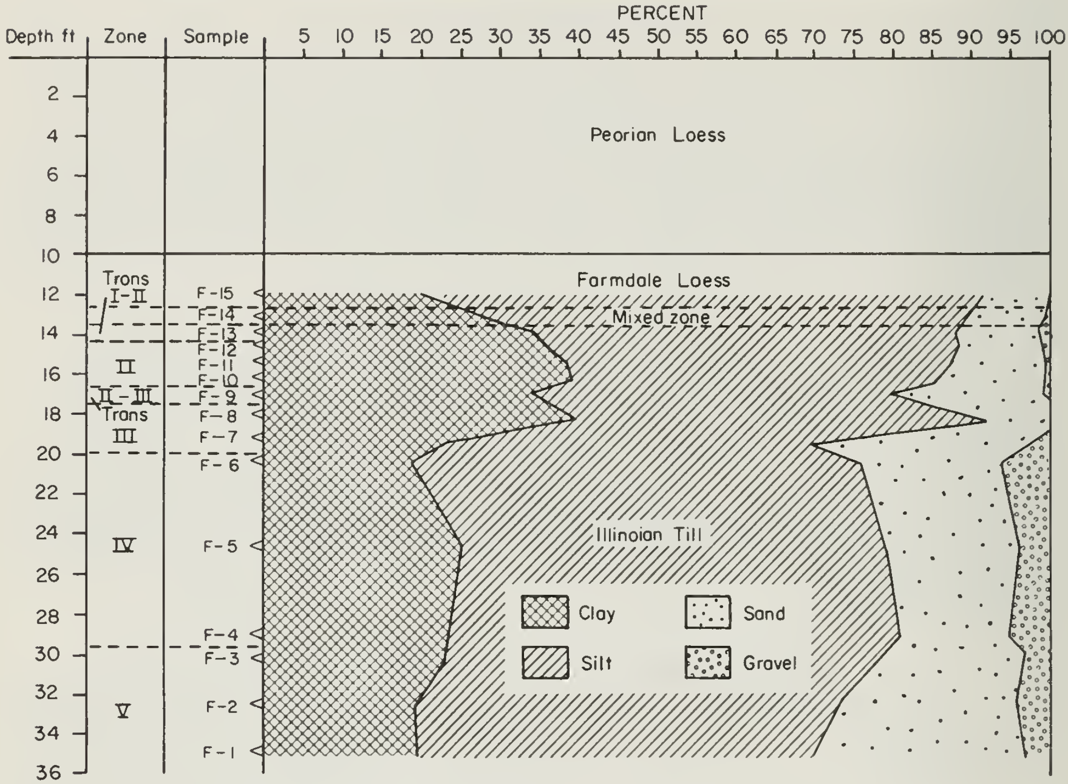

Fig. 3. - Grain size profile of Flamingo section.

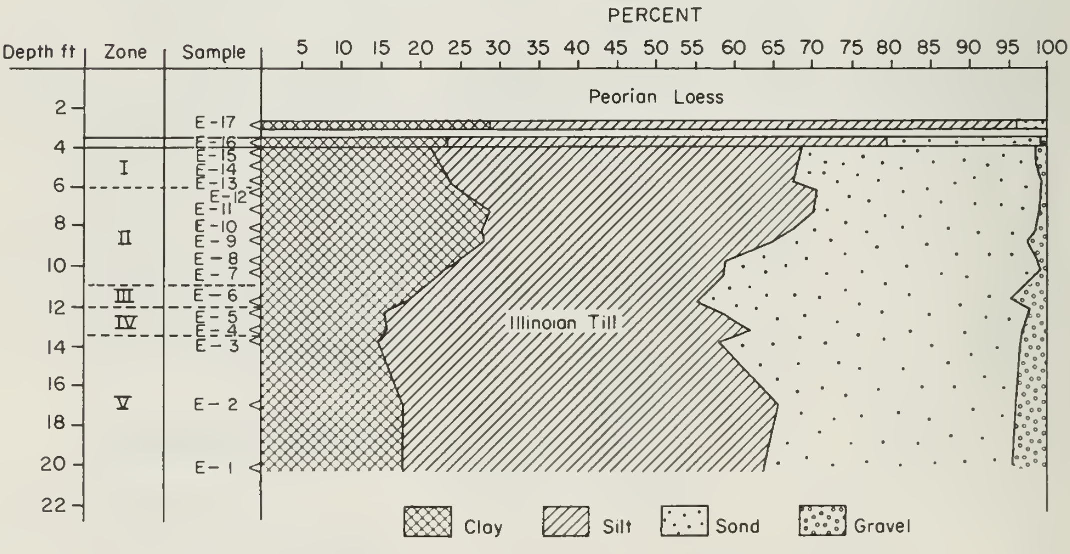

Fig. 4. - Grain size profile of Effingham section.

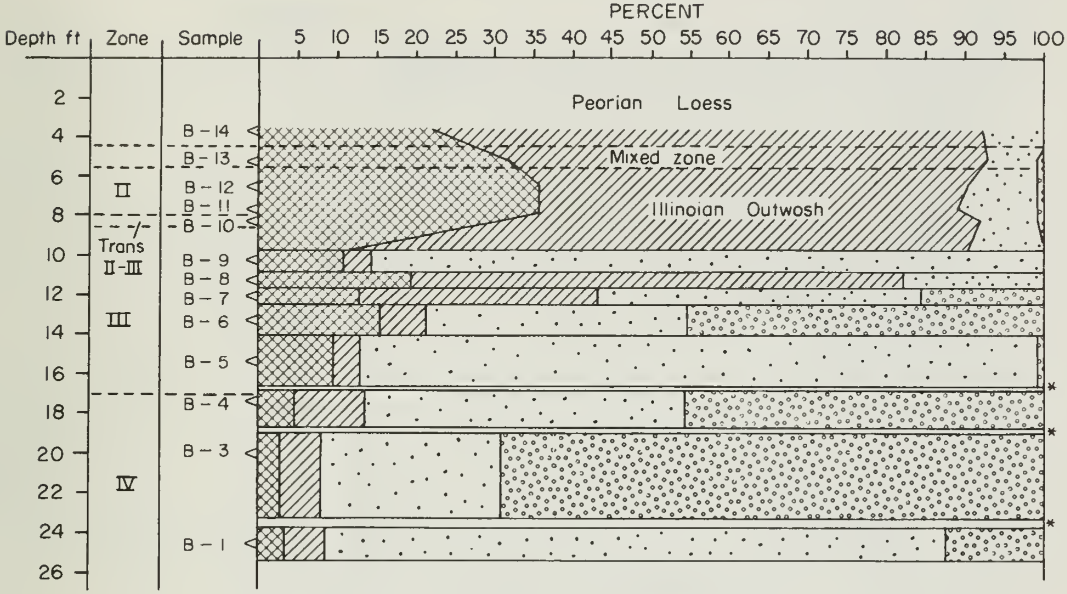

Fig. 5. - Grain size profile of Breeds section.

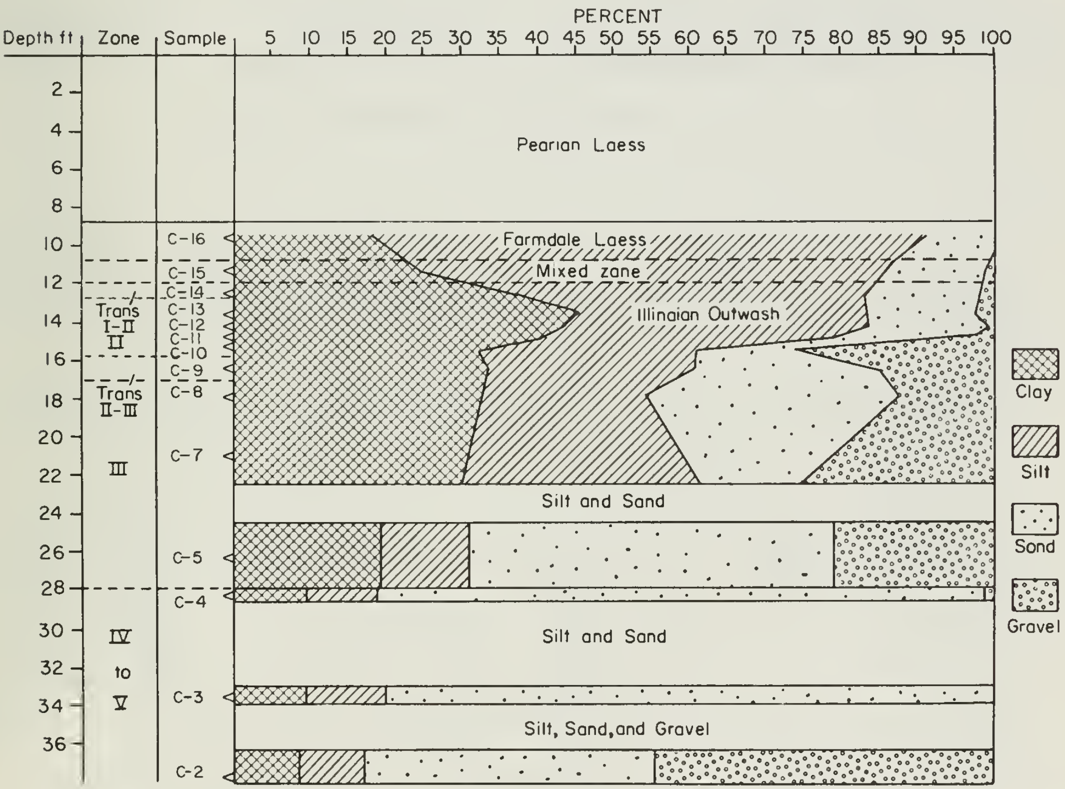

Fig. 6. - Grain size profile of Country Club section.

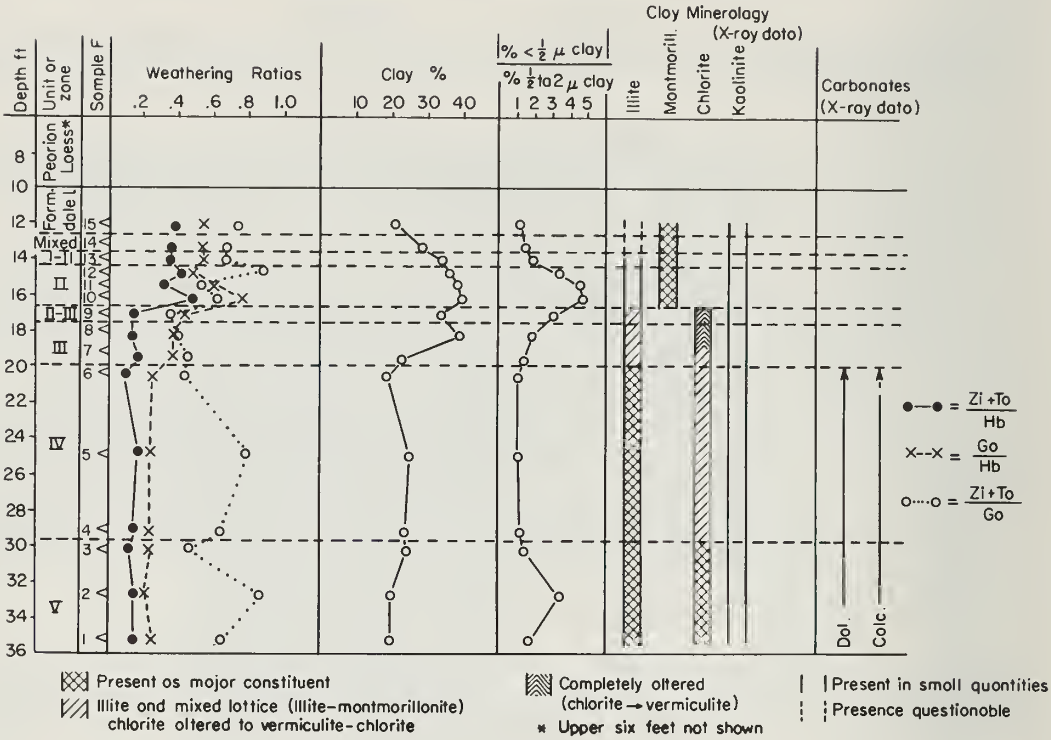

Fig. 7. - Weathering data for Flamingo section

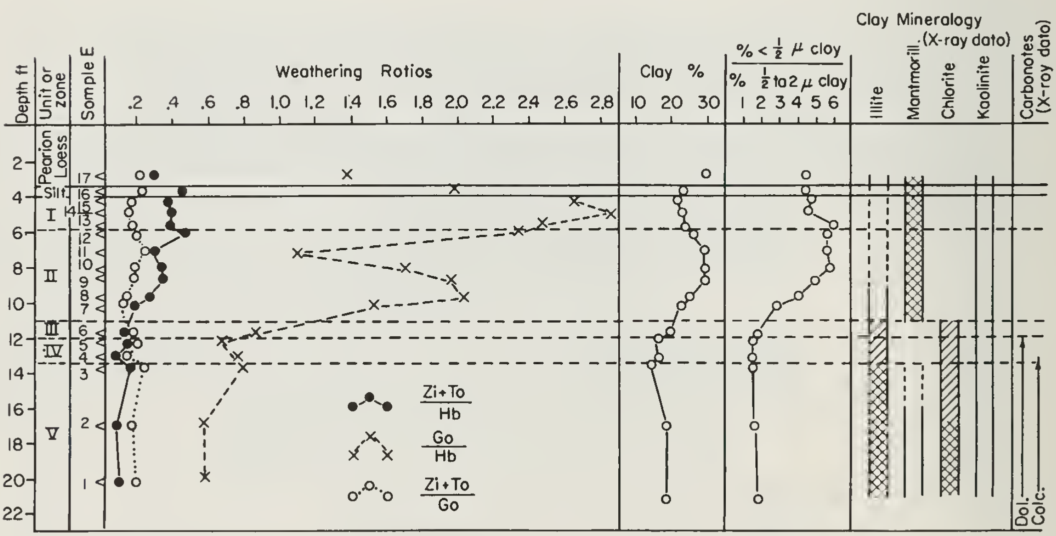

Fig. 8. - Weathering data for Effingham section.

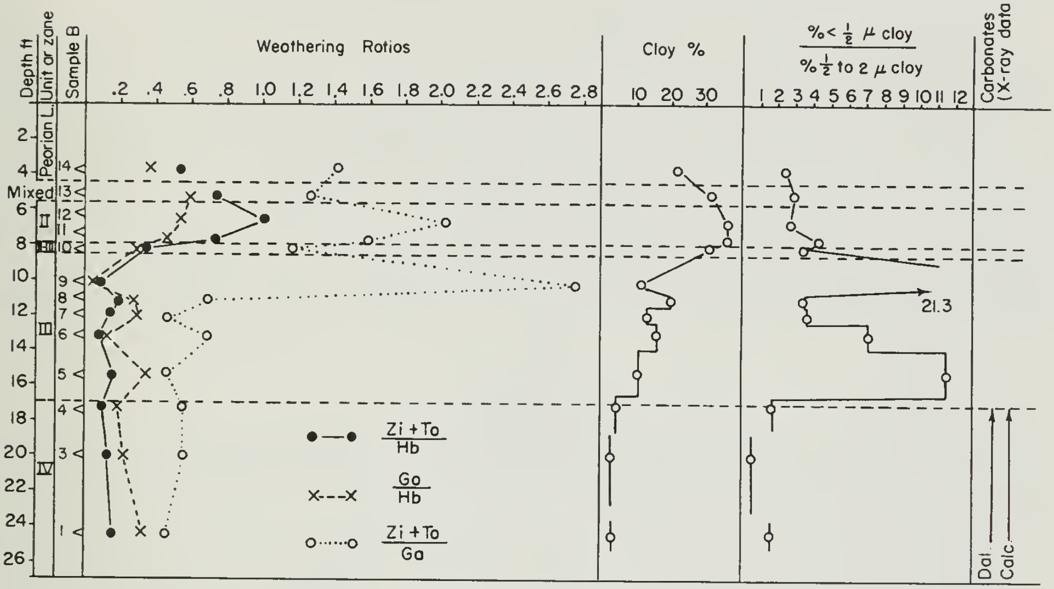

Fig. 9. - Weathering data for Breeds section.

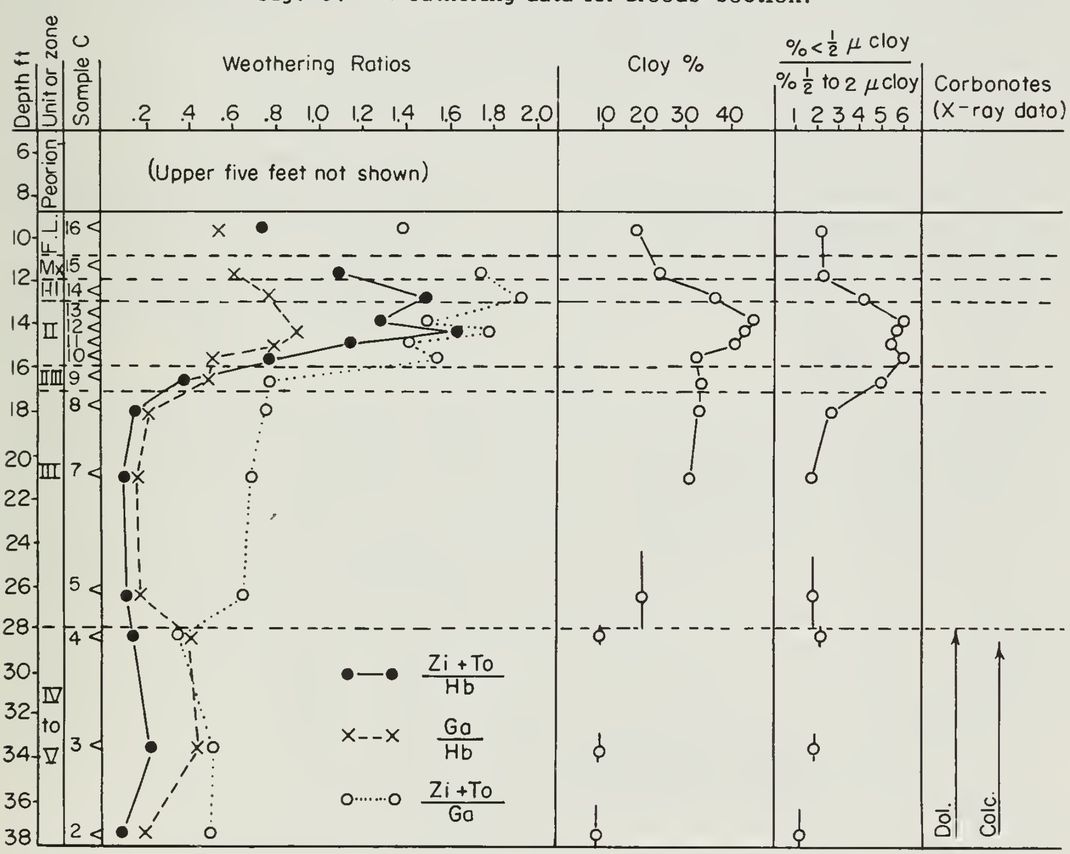

Fig. 10. - Weathering data for Country Club section.

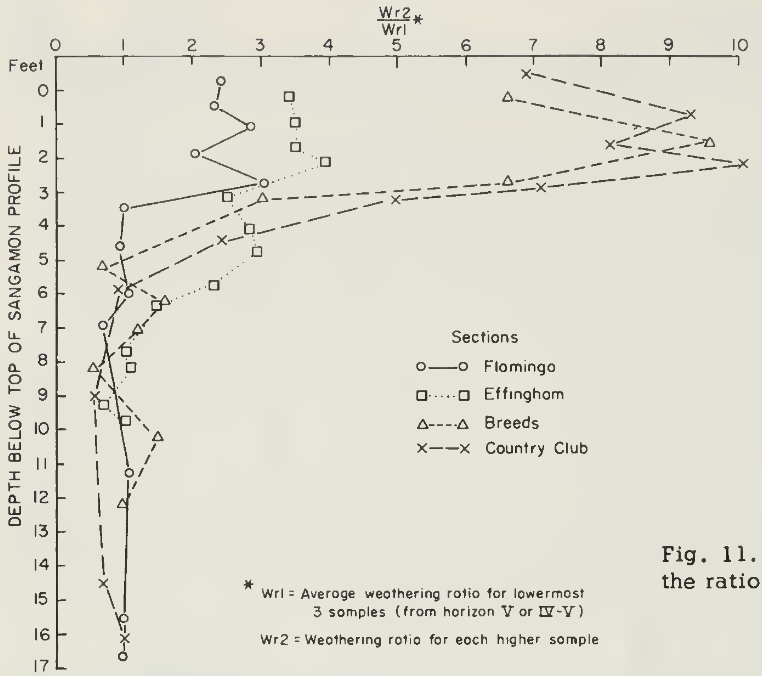

Fig. 11. - Comparative curves for the ratio of zircon-plus-tourmaline to hornblende.

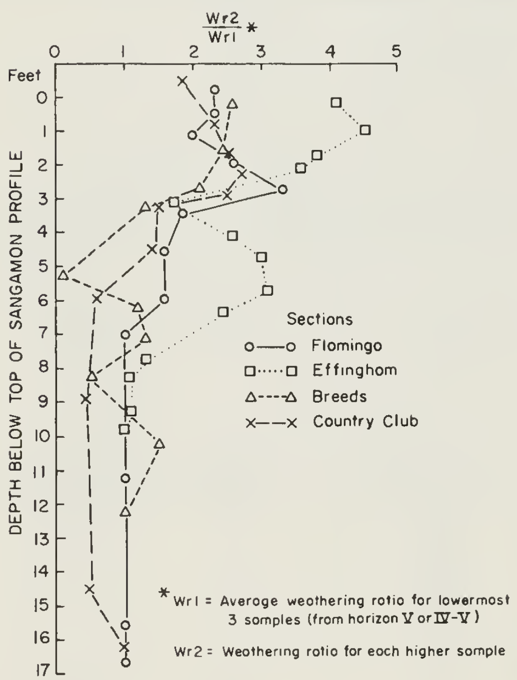

Fig. 12A. - Comparative curves for the ratio of garnet to hornblenue.

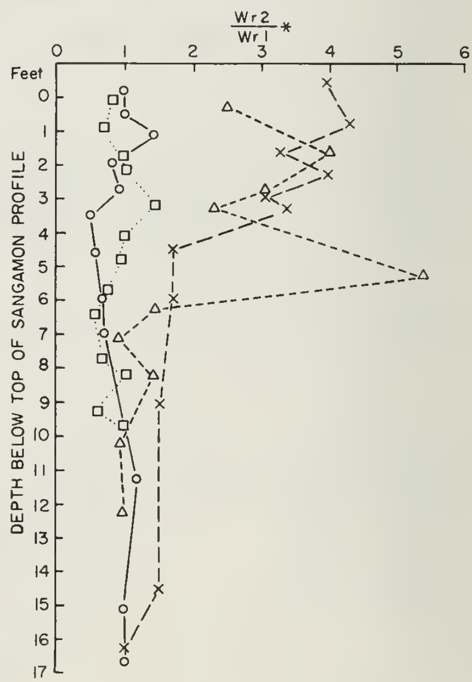

Fig. 12B. - Comparative curves for the ratio of zircon-plus-tourmaline to garnet.

The difference in degree of weathering between the till profiles and the outwash profiles is striking. Not only has hornblende undergone considerably more depletion by weathering in the outwash profiles (fig. 11), but garnet, which shows no loss by weathering in the till profiles, has been partially weathered out of the upper zones of both outwash profiles (fig. 12). Quantitatively, there has been a loss of about 90 percent of hornblende in zone II of the outwash profiles compared to a loss of about 60 percent in the till profiles. Loss of garnet is about 70 percent in the outwash compared to little or no loss in the till.

The depth to which carbonates are leached provides additional evidence of the greater degree of weathering that has occurred in the outwash profiles. Depth of leaching averages about 14 feet in the outwash but only about 7 feet in the till.

DISCUSSION

The observed differences in degree of weathering are considered to be related primarily to differences in texture of the parent material. The relatively coarse-grained outwash sediments certainly would have been the more permeable to weathering solutions, thus facilitating decomposition and removal of the soluble products. In the relatively fine-grained till profiles slow percolation rates would have allowed a higher percentage of the precipitation falling upon them to run off or to be removed by plant transpiration. A number of pedologists (cited by Jenny, 1941), following other lines of evidence, have observed the same relationship of parent-material textures to soil development.

This study also indicated that the resistance of garnet falls between that of hornblende and the zircon-tourmaline group, under the weathering conditions that prevailed. More research is needed to determine why garnet is not depleted in the till profiles, which have lost 60 percent of their hornblende, and yet is strongly depleted in the outwash profiles, which have lost only 30 percent more hornblende.

From this study and those of Ruhe (1956), weathering ratios appear to be a promising method of evaluating profile maturity, especially in buried profiles where standard pedologic tests of maturity may not work.

Clay Mineralogy

Zone II of the profiles is considerably enriched in clay (figs. 7-10). Ratios of the percentage of minus $\frac{1}{2}$-micron clay to $\frac{1}{2}$- to 2-micron clay show that most of the clay added to this zone is in the minus $\frac{1}{2}$-micron fraction. To determine the relationship of this clay increase to the increase in the heavy mineral ratios, clay mineral analyses were made of both till sections by Herbert D. Glass, using a General Electric XRD 3 recording spectrometer. The results of the analyses are graphed in figures 7 and 8 and are discussed below.

Clay minerals of zone V are predominantly illite and chlorite. Chlorite begins to show alteration in the oxidized calcareous till (zone IV) and becomes progressively more altered upward in the profile, changing first to mixed vermiculite-chlorite, then to vermiculite, and finally, in zones II and I, to montmorillonite. The first appearance of substantial illite alteration occurs somewhat higher in the profile than that of chlorite, although illite probably is slightly altered at lower levels. Illite goes through a mixed-lattice illite-montmorillonite stage, with montmorillonite becoming more dominant upward in the profile until, in zones II and I, alteration is nearly complete. Montmorillonite, therefore, is the clay mineral producing the increased percentage of minus $\frac{1}{2}$-micron clay in zone II.

The close correspondence between the base of the montmorillonite zone and the base of the zone of hornblende depletion (essentially the base of zone II) suggests that the montmorillonite may have acted as an acid clay in the breakdown of the hornblende. Graham (1941) showed by experiments that montmorillonite as an acid clay can be highly effective in weathering of minerals.

SUMMARY

Weathering ratio studies show that there can be considerable differences in degree of weathering between Sangamon profiles developed in till and those developed in outwash. Because other factors of soil formation were about the same for both till and outwash profiles, it is concluded that the differences in degree of weathering were caused primarily by differences in texture of parent material.

In the profiles studied, the base of the zone of clay enrichment coincides with the base of the montmorillonitic zone and the base of the zone of maximum depletion of hornblende and garnet.

Weathering ratios seem to hold promise for evaluating maturity of weathering profiles.

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APPENDIX

DESCRIPTION OF PROFILES

In the following descriptions, color determinations are from the Munsell Soil Color Charts. Textural nomenclature is that devised by Shepard (1954). Clay size is taken as < 2 microns. Where pebbles or coarser stones are important constituents, the words "pebbly" or "cobbly" are added. Where these coarser constituents are dominant, Shepard's system is not used. Pedologic textural nomenclature (in parentheses) and soil structure nomenclature are as recommended by the Soil Survey Staff (1951). The term "gravelly" in pedologic textural nomenclature is strictly a size term.

Flamingo Section

Location: Abandoned highwall of Fairview Collieries Flamingo Mine, NW$\frac{1}{4}$ SW$\frac{1}{4}$ NW$\frac{1}{4}$ sec. 31, T. 8 N., R. 3 E., Fulton County, Illinois (Canton quadrangle).

Sangamon topography: Broad, nearly flat upland divide, probably sloping slightly to the northwest.
Elevation of Sangamon surface: 677'± (estimated from topographic map).
Exposure faces north, moisture content normal.
Description compiled from field and laboratory data:

	Unit thickness (ft.)	Unit thickness (in.)	Aggregate thickness (ft.)	Aggregate thickness (in.)
Peorian Loess				
Modern soil at top, noncalcareous to 7 feet, calcareous from 7 to 10 feet	10	0	10	0
Farmdale Loess				
Yellowish brown (10YR 5/4) clayey silt (silt loam), noncalcareous	2	6	12	6
Mixed zone				
Yellowish brown (10YR 5/4) clayey silt (silty clay loam), slightly more clayey than unit above, a few scattered pebbles, noncalcareous	1	0	13	6
Illinoian Till with Sangamon weathering profile				
Transition, zone I to zone II				
Dark grayish brown (10YR 4/2) clayey silt (silty clay loam), moderate fine subangular blocky structure, clay skins on peds, numerous large borings of crayfish type, a few small pebbles, noncalcareous	0	9	14	3
Zone II				
Brown (10YR 4/3) clayey silt (silty clay loam), more clayey than unit above, moderate fine blocky structure at top to strong coarse blocky structure at base; shows prismatic tendency				

	(ft.	in.)	(ft.	in.)
on dry face, clay skins prominent (color above is that of clay skins, ped interiors are brownish yellow [10YR 6/6]), a few small pebbles, noncalcareous..................	2	3	16	6
Transition, zone II to zone III				
Mottled 50 percent brownish yellow (10YR 6/6) and 50 percent light olive gray (5Y 6/2) sand-silt-clay (silty clay loam), very weak, very coarse blocky structure, texture more till-like than above, pebbles slightly more numerous and larger than above, noncalcareous..............................	1	0	17	6
Zone III				
Mottled brownish yellow (10YR 6/6) and light olive gray (5Y 6/2) clayey silt (silty clay loam) to pebbly sand-silt-clay (gravelly loam), structureless, brownish yellow mottles increase downward from about 50 percent to about 90 percent; texture shows some effects of water sorting (some sandy lenses and some finer grained zones), pebbles larger and more numerous than above, noncalcareous......	2	5	19	11
Zone IV				
Light yellowish brown (10YR 6/4) pebbly sandy silt (gravelly silt loam) to pebbly sand-silt-clay (heavier gravelly silt loam); strong brown (7.5YR 5/6) appears along joints at 6 feet and continues to base of zone IV; matrix gradually changes downward from light yellowish brown to light brownish gray (2.5Y 6/2) near the base; contains pebbles, cobbles and a few boulders, calcareous..............................	9	8	29	7
Zone V				
Gray (5Y 5/1) pebbly sandy silt (gravelly silt loam) to pebbly sand-silt-clay (heavier gravelly silt loam), contact sharp with unit above, though oxidation continues down along joints; contains pebbles, a few cobbles and a few boulders, calcareous...........	6	0	35	7

Covered below.

Effingham Section
(first described by Leighton and MacClintock [1930])

Location: North wall of drainage ditch, center sec. 6, T. 7 N., R. 6 E., Effingham County, Illinois (Effingham quadrangle).

Sangamon topography: Very flat upland divide.
Elevation of Sangamon surface: 577'± (estimated from topographic map).
Exposure faces south, moisture content normal.
Description compiled from field and laboratory data:

	Unit thickness (ft.)	(in.)	Aggregate thickness (ft.)	(in.)
Peorian Loess				
Modern planosolic soil at top, noncalcareous..	3	5	3	5
Farmdale?				
Gray (10YR 6/1) sand-silt-clay (silt loam) with black streaks, may be part of Sangamon profile mixed with loess, noncalcareous..............................	0	7	4	0
Illinoian Till with Sangamon weathering profile				
Zone I				
Gray (10YR 5.5/1) sand-silt-clay (loam), mottled 10 percent (at top) to 50 percent (at base) with yellowish brown (10YR 5/6 to 5/8), a few quartz and chert pebbles, noncalcareous........................	1	11	5	11
Zone II				
Dark gray (10YR 4/1) to gray (10YR 5/1) sand-silt-clay (loam to clay loam), yellowish brown (10YR 5/6) mottling at top increases downward until it becomes the predominant color at about 2½ feet below top, structureless, clay decreases downward, pebbles (mostly chert) larger and more abundant than above but still not common, lower part gradually transitional to zone III, many crayfish-type borings, noncalcareous.............	5	1	11	0
Zone III				
Yellowish brown (10YR 5/8) pebbly silty sand (gravelly loam), mottled about 5 percent with light gray (10YR 6/1), texture more till-like, some thin sand and gravel beds in this part of profile, noncalcareous......	1	0	12	0
Zone IV				
Light yellowish brown (10YR 6/4) pebbly silty sand to pebbly sandy silt (gravelly loam), very compact, coatings of gray (N 6/0) on vertical and horizontal fracture surfaces, calcareous...........................	1	5	13	5
Zone V				
Gray (5Y 5/1) pebbly sandy silt (gravelly loam), extremely compact, gray (N 5/0) coatings on fracture surfaces, slightly oxidized to grayish brown (2.5Y 5/2) along joints, calcareous................	7	6	20	11

Covered below.

Country Club Section

Location: Abandoned highwall of Truax-Traer Fiatt Mine 2, now on property of Wee-ma-tuk Country Club, SE$\frac{1}{4}$ SW$\frac{1}{4}$ NW$\frac{1}{4}$ sec. 2, T. 6 N., R. 3 E., Fulton County, Illinois (Canton quadrangle).

Sangamon topography: Essentially flat upland divide, may have had slight westward slope.
Elevation of Sangamon surface: 660'± (estimated from topographic map).
Exposure faces north, moisture content normal.
Description compiled from field and laboratory data:

	Unit thickness (ft.)	Unit thickness (in.)	Aggregate thickness (ft.)	Aggregate thickness (in.)
Peorian Loess				
Modern soil at top, noncalcareous	8	8	8	8
Farmdale Loess				
Dark grayish brown (10YR 4/2) clayey silt (silt loam), contains scattered flakes of carbonaceous matter, noncalcareous	2	0	10	8
Mixed Zone				
Brown (10YR 4/3) clayey silt (silt loam), probably a mixture of Farmdale Loess and zone I material of Sangamon profiles, noncalcareous	1	2	11	10
Illinoian outwash with Sangamon weathering profile				
Transition, zone I to zone II				
Yellowish brown (10YR 5/4) to dark yellowish brown (10YR 3/4) clayey silt (silty clay loam), very weak medium subangular blocky structure, clay skins on peds, some iron oxide pellets ("buckshot"), noncalcareous	0	11	12	9
Zone II				
Dark brown (10YR 4/3) silty clay (clay), moderate medium subangular blocky structure, clay skins on peds, noncalcareous	1	9	14	6
Zone II and Transition, zone II to zone III				
Mottled light brownish gray (10YR 6/2), yellowish brown (10YR 5/6), and black (N 2/0) silty clay (clay), changing downward to pebbly sand-silt-clay (gravelly clay loam), weak, medium to coarse blocky structure, contains resistant pebbles up to 2 inches in diameter, noncalcareous	2	6	17	0
Zone III				
Strong brown (7.5YR 5/6) cobbly, pebbly sand-silt-clay (cobbly, gravelly clay loam to sandy clay loam), structureless, some indications of bedding, numerous large borings of crayfish type extend about halfway down, noncalcareous. This and the				

	Unit (ft.	in.)	Aggregate (ft.	in.)
units above may be the weathered remains of a water-laid till or a very poorly sorted outwash deposit	5	6	22	6
Units below are definitely outwash.				
Interbedded sand and silt, noncalcareous, (not sampled)	2	0	24	6
Multicolored but predominantly strong brown (7.5YR 5/8) pebbly clayey sand (gravelly sandy loam), noncalcareous	3	6	28	0
Zone IV to V				
Light brown (10YR 6/4) sand (loamy sand), clean, well sorted, calcareous	0	6	28	6
Interbedded sand and silt, calcareous, (not sampled)	4	4	32	10
Multicolored but predominantly light brown (10YR 6/3) sand (loamy sand), weak iron oxide cementing, calcareous	1	0	33	10
Interbedded sand, silt, and gravel, calcareous (not sampled)	2	4	36	2
Multicolored, very poorly sorted water-laid sediment, predominantly a very coarse gravel, but containing all sizes from 2-foot boulders to clay, calcareous	6	0	42	2
Silt and sand, calcareous (not sampled)	1	5	43	7

Covered below.

Breeds Section

Location: Gravel pit, SE$\frac{1}{4}$ NE$\frac{1}{4}$ NW$\frac{1}{4}$ sec. 33, T. 7 N., R. 5 E., Fulton County, Illinois (Glasford quadrangle).

Sangamon topography: Essentially flat upland divide.
Elevation of Sangamon surface: 575'± (estimated from topographic map).
Exposure faces south, extremely dry.
Description compiled from field and laboratory data:

	Unit thickness (ft.	in.)	Aggregate thickness (ft.	in.)
Peorian Loess				
Modern soil at top, lower foot or so may be Farmdate Loess (extreme dryness made differentiation uncertain), very pale brown (10YR 7/4) clayey silt (silt loam), noncalcareous	4	6	4	6
Mixed zone				
Light yellowish brown (10YR 6/4) clayey silt (silty clay loam), noncalcareous	1	0	5	6

	Thickness (ft.)	(in.)	Depth (ft.)	(in.)
Illinoian outwash with Sangamon profile of weathering				
Zone II				
Dark yellowish brown (10YR 4/4) clayey silt (silty clay loam), mottled with strong brown (7.5YR 5/8); strong medium prismatic structure becoming coarse near base; large crayfish-type borings, clay skins prominent, noncalcareous	2	6	8	0
Transition, zone II to zone III				
Very pale brown (10YR 7/3) clayey silt (silty clay loam), mottled with brownish yellow (10YR 6/6), moderate very coarse blocky structure, a few clay skins, noncalcareous	0	6	8	6
Zone III				
Same as unit above, but less clayey, structureless, noncalcareous (not sampled)	1	3	9	9
Multicolored but predominantly brown (10YR 5/3) sand (loamy sand), noncalcareous	1	2	10	11
Very pale brown (10YR 7/3) clayey silt (silt loam), strong brown (7.5YR 5/6) stain along joint faces, noncalcareous	0	9	11	8
Pale brown (10YR 6/3) pebbly silty sand (gravelly sandy loam), pebbles are scattered in sand matrix, noncalcareous	0	11	12	7
Multicolored but predominantly dark yellowish brown (10YR 4/4) poorly sorted deposit, predominantly gravel and sand with some clay and a small amount of silt; a few large limestone or dolomite "ghost" pebbles, but matrix is noncalcareous	1	7	14	2
Reddish yellow (7.5YR 6/6) sand (loamy sand), contains a few silt layers, noncalcareous	2	6	16	8
Silt, noncalcareous (not sampled)	0	2	16	10
Strong brown (7.5YR 5/6) sandy gravel, noncalcareous	0	3	17	1
Yellowish brown (10YR 5/4) sandy gravel (same bed as unit above, but calcareous)	1	9	18	10
Laminated silt and sand, calcareous (not sampled)	0	2	19	0
Multicolored sandy gravel, calcareous	4	3	23	3
Pebbly silty sand, calcareous (not sampled)	0	5	23	8
Multicolored pebbly sand (gravelly sand), faintly oxidized, calcareous	1	6	25	2

Covered below.

TABLE A. - MECHANICAL COMPOSITION OF SECTIONS

(All figures in percent by weight)

Sample	Gravel (>2.362 mm)	Very coarse sand (<2.362>1.000 mm)	Coarse sand (<1.000>.500 mm)	Medium sand (<.500>.250 mm)	Fine sand (<.250>.125 mm)	Very fine sand (<.125>.062 mm)	Total sand (<2.362>.062 mm)	Coarse silt (<.062>.030 mm)	Medium silt (<.030>.010 mm)	Fine silt (<.010>.005 mm)	Very fine silt (<.005>.002 mm)	Total silt (<.062>.002 mm)	Coarse clay (<.002>.001 mm)	Medium clay (<.001>.0005 mm)	Fine to very fine clay (<.0005 mm)	Total clay (<.002 mm)
FLAMINGO SECTION																
F-15	0.08	0.42	1.12	2.69	2.59	1.60	8.42	13.86	36.00	11.88	9.18	70.92	5.24	4.66	10.68	20.58
F-14	0.47	1.09	1.18	3.12	3.26	2.18	10.83	12.92	28.96	10.32	8.30	60.50	5.76	5.54	16.90	28.20
F-13	1.28	0.79	0.99	3.12	3.54	2.51	10.95	11.17	25.64	9.66	7.18	53.65	5.34	6.26	22.52	34.12
F-12	0.63	0.78	1.01	3.31	3.59	2.53	11.22	11.37	25.30	8.64	7.04	52.35	3.80	4.50	27.50	35.80
F-11	0.66	0.81	1.05	3.61	3.84	2.74	12.05	11.19	22.90	7.92	6.92	48.93	3.14	3.76	31.46	38.36
F-10	0.22	0.67	1.17	4.49	4.52	3.32	14.17	15.37	18.78	6.96	5.06	46.17	3.44	3.36	32.64	39.44
F-9	0.40	1.94	2.30	6.31	5.72	3.91	20.18	10.14	17.50	9.28	8.82	45.74	4.80	3.58	25.30	33.68
F-8	-	0.48	0.62	1.93	2.45	2.85	8.33	8.69	12.64	13.70	17.48	52.51	7.78	5.86	25.52	39.16
F-7	2.57	1.70	2.56	8.55	9.41	6.04	28.26	11.37	15.26	9.12	10.80	46.55	5.10	4.30	13.22	22.62
F-6	6.21	1.28	0.71	2.31	6.73	7.59	18.62	15.29	20.34	10.90	10.34	56.87	5.22	3.40	9.68	18.30
F-5	3.92	1.40	1.12	3.21	5.67	5.47	16.87	12.31	20.90	10.88	10.12	54.21	6.68	5.00	13.32	25.00
F-4	5.33	1.28	0.90	2.77	4.56	4.29	13.80	13.45	20.52	11.40	11.96	57.33	6.04	4.46	13.04	23.54
F-3	3.14	1.53	1.45	4.08	5.79	5.57	18.42	12.94	21.08	10.28	11.04	55.34	5.28	3.94	13.88	23.10
F-2	4.41	1.59	0.33	1.23	9.00	10.21	22.76	15.19	19.54	10.56	8.48	53.77	4.18	0.20	14.68	19.06
F-1	3.35	2.56	2.73	7.15	8.36	6.24	27.04	12.15	18.06	11.40	8.52	50.13	3.78	3.32	12.38	19.48

TABLE A. - MECHANICAL COMPOSITION OF SECTIONS - (Continued)

(All figures in percent by weight)

Sample	Gravel (>2.362 mm)	Very coarse sand (<2.362>1.000 mm)	Coarse sand (<1.000>.500 mm)	Medium sand (<.500>.250 mm)	Fine sand (<.250>.125 mm)	Very fine sand (<.125>.062 mm)	Total sand (<2.362>.062 mm)	Coarse silt (<.062>.030 mm)	Medium silt (<.030>.010 mm)	Fine silt (<.010>.005 mm)	Very fine silt (<.005>.002 mm)	Total silt (<.062>.002 mm)	Coarse clay (<.002>.001 mm)	Medium clay (<.001>.0005 mm)	Fine to very fine clay (<.0005 mm)	Total clay (<.002 mm)
EFFINGHAM SECTION																
E-17	-	0.47	0.67	1.04	0.97	0.72	3.87	8.59	37.94	12.94	7.84	67.31	3.00	2.42	23.40	28.82
E-16	0.76	0.51	1.61	6.88	7.05	3.85	19.90	11.38	29.14	9.32	6.32	56.16	2.40	1.94	18.84	23.18
E-15	1.46	1.18	2.24	9.99	10.69	6.07	30.17	11.59	22.96	7.16	4.82	46.53	2.00	1.82	18.02	21.84
E-14	1.33	0.95	2.80	10.85	10.36	5.77	30.73	10.90	23.06	6.70	4.42	45.08	2.40	1.76	18.70	22.86
E-13	0.95	0.88	3.04	11.68	10.18	5.64	31.42	11.43	21.02	6.92	4.48	43.85	2.32	1.08	20.38	23.78
E-12	0.99	0.98	2.69	10.18	9.39	5.37	28.61	11.28	22.02	7.40	4.52	45.22	2.22	1.58	21.38	25.18
E-11	0.95	0.91	3.03	10.68	9.18	5.14	28.94	10.77	20.40	6.08	4.06	41.31	2.56	1.84	24.40	28.80
E-10	1.42	1.16	2.50	10.90	10.66	6.16	31.38	11.20	18.04	6.56	3.58	39.38	2.10	2.02	23.70	27.82
E-9	2.66	1.43	2.19	9.70	11.99	7.54	32.85	11.57	15.78	5.34	3.76	36.45	2.48	2.28	23.28	28.04
E-8	1.10	1.74	4.30	14.23	12.03	7.53	39.83	11.25	14.58	5.04	3.36	34.23	2.92	2.10	19.82	24.84
E-7	0.88	2.11	4.49	13.76	13.00	7.41	40.87	10.83	13.44	6.96	5.00	36.23	3.06	2.80	16.26	22.12
E-6	4.93	1.68	2.57	11.55	15.17	9.02	39.99	10.68	13.36	6.88	6.10	37.02	3.34	3.16	11.56	18.06
E-5	2.27	2.95	4.03	11.49	12.66	8.14	39.27	13.82	16.12	7.36	6.08	43.38	3.22	2.74	9.12	15.08
E-4	2.96	1.99	1.76	8.20	13.54	9.67	35.16	14.42	17.40	7.96	6.72	46.50	3.44	3.10	8.84	15.38
E-3	3.47	3.51	4.30	11.02	11.78	7.74	38.35	12.34	16.98	7.44	6.66	43.42	3.52	2.80	8.44	14.76
E-2	2.98	3.47	2.71	7.25	10.36	7.58	31.37	11.83	18.70	9.18	7.84	47.55	3.98	3.26	10.86	18.10
E-1	4.11	3.41	2.93	7.50	10.64	7.87	32.35	12.86	18.60	7.84	6.46	45.76	3.84	2.64	11.30	17.78

TABLE A. - MECHANICAL COMPOSITION OF SECTIONS - (Continued)

(All figures in percent by weight)

Sample	Gravel (>2.362 mm)	Very coarse sand (<2.362>1.000 mm)	Coarse sand (<1.000>.500 mm)	Medium sand (<.500>.250 mm)	Fine sand (<.250>.125 mm)	Very fine sand (<.125>.062 mm)	Total sand (<2.362>.062 mm)	Coarse silt (<.062>.030 mm)	Medium silt (<.030>.010 mm)	Fine silt (<.010>.005 mm)	Very fine silt (<.005>.002 mm)	Total silt (<.062>.002 mm)	Coarse clay (<.002>.001 mm)	Medium clay (<.001>.0005 mm)	Fine to very fine clay (<.0005 mm)	Total clay (<.002 mm)
BREEDS SECTION																
B-14	-	0.41	0.82	1.76	2.30	2.25	7.54	15.50	35.02	11.76	8.00	70.28	3.64	3.02	15.52	22.18
B-13	0.25	0.75	0.50	1.13	2.09	2.54	7.01	10.48	28.32	12.70	9.26	60.76	3.94	4.22	23.82	31.98
B-12	0.18	0.32	0.55	1.17	2.54	4.98	9.56	12.72	24.72	9.12	7.86	54.42	4.42	5.12	26.30	35.84
B-11	0.11	0.19	0.58	1.74	4.23	4.71	11.45	11.92	22.98	9.84	7.82	52.56	3.66	3.22	29.00	35.88
B-10	0.18	0.77	0.82	1.25	1.43	3.23	7.50	12.26	30.78	10.60	7.76	61.40	3.98	3.04	23.90	30.92
B-9	-	2.67	25.41	54.52	2.32	0.63	85.55	1.15	1.33	0.50	0.55	3.53	0.24	0.25	10.43	10.92
B-8	-	0.26	0.50	2.41	6.94	7.68	17.79	17.17	31.46	8.12	5.96	62.71	2.52	1.94	15.04	19.50
B-7	15.47	3.88	2.48	11.11	15.43	8.70	41.60	10.23	12.04	4.00	3.90	30.17	1.86	0.88	10.02	12.76
B-6	45.23	8.80	9.26	11.49	3.03	0.75	33.33	1.44	1.92	1.01	1.58	5.95	0.96	0.97	13.56	15.49
B-5	0.35	0.43	6.86	60.49	17.25	1.68	86.71	0.88	1.30	0.51	0.32	3.01	0.50	0.30	9.13	9.93
B-4	45.27	11.19	12.06	13.65	2.84	1.12	40.86	2.46	3.94	1.46	1.43	9.29	0.78	0.89	2.91	4.58
B-3	68.91	13.69	3.71	3.47	1.60	0.46	22.93	0.85	1.73	1.12	1.45	5.15	0.97	0.89	1.15	3.01
B-1	12.21	17.19	28.40	25.82	6.94	0.75	79.10	1.17	2.44	0.82	1.04	5.47	0.61	0.66	1.95	3.22

TABLE A. - MECHANICAL COMPOSITION OF SECTIONS - (Continued)

(All figures in percent by weight)

Sample	Gravel (>2.362 mm)	Very coarse sand (<2.362>1.000 mm)	Coarse sand (<1.000>.500 mm)	Medium sand (<.500>.250 mm)	Fine sand (<.250>.125 mm)	Very find sand (<.125>.062 mm)	Total sand (<2.362>.062 mm)	Coarse silt (<.062>.030 mm)	Medium silt (<.030>.010 mm)	Fine silt (<.010>.005 mm)	Very fine silt (<.005>.002 mm)	Total silt (<.062>.002 mm)	Coarse clay (<.002>.001 mm)	Medium clay (<.001>.0005 mm)	Fine to very fine clay (<.0005 mm)	Total clay (<.002 mm)
							COUNTRY CLUB SECTION									
C-16	-	0.27	0.79	2.78	2.89	2.13	8.86	14.22	40.72	10.92	7.04	72.90	2.82	2.94	12.48	18.24
C-15	0.70	0.51	1.14	3.95	4.52	3.58	13.70	12.86	31.26	10.72	6.82	61.66	3.46	3.70	16.78	23.94
C-14	1.60	1.10	0.98	3.63	5.20	4.42	15.33	8.89	21.38	8.72	7.48	46.47	3.24	3.60	29.76	36.60
C-13	2.18	0.86	1.23	3.66	4.94	4.20	14.89	7.69	16.16	7.50	6.14	37.49	3.66	2.82	38.96	45.44
C-12	0.80	1.14	1.69	4.50	4.89	3.90	15.92	8.30	18.06	6.80	6.50	39.66	3.32	3.18	37.12	43.62
C-11	2.04	1.22	1.43	4.97	5.90	5.13	18.65	8.53	17.00	7.08	5.52	38.13	3.64	2.72	34.82	41.18
C-10	26.46	0.68	0.76	2.49	4.32	4.26	12.51	6.14	12.01	4.76	6.03	28.94	2.69	1.90	27.50	32.09
C-9	15.35	1.86	3.11	8.52	6.59	3.94	24.02	4.91	5.41	10.68	6.21	27.21	2.91	2.61	27.90	33.42
C-8	12.56	5.51	6.77	13.95	5.09	2.41	33.73	5.20	5.36	3.85	6.70	21.11	4.49	4.12	23.99	32.60
C-7	21.32	5.42	3.37	4.22	3.52	2.96	19.49	4.94	8.33	5.57	9.49	28.33	6.35	4.71	19.80	30.86
C-5	21.19	8.69	16.64	17.66	3.70	1.09	47.78	2.00	2.85	2.62	4.03	11.50	3.29	3.47	12.77	19.53
C-4	1.08	0.25	10.40	54.61	12.94	2.65	79.85	2.99	2.46	1.80	2.07	9.32	1.45	1.64	6.66	9.75
C-3	-	0.04	0.40	14.91	55.57	8.56	79.48	3.45	3.39	1.81	2.37	10.66	1.54	1.73	6.23	9.50
C-2	44.16	14.13	11.27	10.00	2.67	0.90	38.97	2.09	1.96	1.50	2.62	8.17	2.06	1.80	4.84	8.70

TABLE B. - HEAVY MINERAL DATA

Illinoian Till Sections

Sample	Unit or zone	No.* Ga	No. Zi	No. To	No. Hb	Ga/Hb	Zi+To/Hb	Zi+To/Ga
				FLAMINGO SECTION				
F-15	Farmdale Loess	84	33	28	155	.54	.39	.73
F-14	Mixed	84	36	21	159	.53	.36	.68
F-13	Trans. I-II	84	39	17	160	.53	.35	.67
F-12	II	75	45	22	158	.47	.42	.89
F-11	II	93	30	19	158	.59	.31	.53
F-10	II	103	46	17	134	.77	.47	.61
F-9	Trans. II-III	80	20	8	192	.42	.15	.35
F-8	III	74	15	13	198	.37	.14	.38
F-7	III	71	25	8	196	.36	.17	.46
F-6	IV	53	14	9	224	.24	.10	.43
F-5	IV	45	17	18	203	.22	.17	.78
F-4	IV	51	17	15	217	.24	.15	.63
F-3	V	56	13	13	218	.26	.12	.46
F-2	V	43	25	12	220	.20	.17	.86
F-1	V	50	23	9	218	.23	.15	.64
				EFFINGHAM SECTION				
E-17	Peorian Loess	143	16	13	104	1.38	.28	.20
E-16	Silt	174	30	7	89	1.96	.42	.21
E-15	I	197	22	6	75	2.63	.37	.14
E-14	I	202	19	8	71	2.85	.38	.13
E-13	I	192	24	6	78	2.46	.38	.16
E-12	II	186	29	5	80	2.33	.43	.18
E-11	II	137	20	16	127	1.08	.28	.26
E-10	II	169	22	9	100	1.69	.31	.18
E-9	II	179	23	6	92	1.95	.32	.16
E-8	II	185	15	8	92	2.01	.25	.12
E-7	II	169	16	3	112	1.51	.17	.11
E-6	III	130	14	3	153	.85	.11	.13
E-5	IV	113	17	3	167	.68	.12	.18
E-4	IV	121	10	3	166	.73	.08	.11
E-3	V	121	23	2	154	.79	.16	.21
E-2	V	103	12	3	182	.57	.08	.15
E-1	V	102	13	4	181	.56	.09	.17

*Number of grains in 300 grains of garnet (Ga), zircon (Zi), tourmaline (To), and hornblende (Hb).

TABLE B. - HEAVY MINERAL DATA - (Continued)

Illinoian Outwash Sections

Sample	Unit or zone	No.* Ga	No. Zi	No. To	No. Hb	Ga/Hb	Zi+To/Hb	Zi+To/Ga
				BREEDS SECTION				
B-14	Peorian Loess	59	39	44	158	.37	.53	1.41
B-13	Mixed	75	53	42	130	.58	.73	1.27
B-12	II	61	52	71	116	.53	1.06	2.02
B-11	II	63	46	54	137	.46	.73	1.59
B-10	Trans. II-III	52	27	34	187	.28	.33	1.17
B-9	III	8	18	4	270	.03	.08	2.75
B-8	III	54	21	16	209	.26	.18	.69
B-7	III	59	17	10	214	.28	.13	.46
B-6	III	27	13	6	254	.11	.07	.70
B-5	III	65	21	9	205	.32	.15	.46
B-4	IV	38	11	10	241	.16	.09	.55
B-3	IV	46	16	9	229	.20	.11	.54
B-1	IV	64	19	10	207	.31	.14	.45
				COUNTRY CLUB SECTION				
C-16	Farmdale Loess	70	46	51	133	.53	.73	1.39
C-15	Mixed	68	61	60	111	.61	1.09	1.75
C-14	Trans. I-II	71	77	60	92	.77	1.49	1.93
C-13	II	82	59	64	95	.86	1.29	1.50
C-12	II	77	78	60	85	.91	1.62	1.79
C-11	II	82	63	53	102	.80	1.14	1.41
C-10	II	67	48	55	132	.51	.78	1.54
C-9	Trans. II-III	78	29	32	161	.48	.38	.78
C-8	III	45	15	19	221	.20	.15	.76
C-7	III	36	14	11	239	.15	.10	.69
C-5	III	38	16	9	237	.16	.11	.66
C-4	IV	76	14	13	197	.39	.14	.36
C-3	IV	79	31	9	181	.44	.22	.51
C-2	IV	43	14	7	236	.18	.09	.49

* Number of grains in 300 grains of garnet (Ga), zircon (Zi), tourmaline (To), and hornblende (Hb).

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